CHAPTER 14

UTILITY SYSTEMS

14-1. Introduction. This chapter prescribes the criteria for utility systems and components 5 feet or farther beyond buildings in seismic areas. Utility systems have been classified as being either above grade or underground. Principles, factors, and concepts involved in seismic design are illustrated. These are not mandatory; therefore, other equivalent methods or schemes complying with applicable agency guide specifications and the intent of this manual may be used.

14-2. General. Utility systems will be planned and designed in accordance with the provisions given in this chapter, except as follows—

a. Systems above grade. Utility system components and equipment supports above grade will be designed in accordance with the applicable provisions of chapter 12.

b. Rigorous analysis. No part of this chapter will be construed to prohibit a rigorous analysis of an exterior utility system either above or below grade by established principles of structural dynamics and soil mechanics. Such an analysis must demonstrate that the exterior utility system will withstand, without disrupting service, the ground accelerations and associated deformations induced in the system by a major seismic event. The effect of such an event on the system will be determined using either acceleration-time history records or equivalent response spectra of major seismic events. The actual earthquake record or response spectra used, including artifically generated spectra, will be geologically and seismologically appropriate to the site and may be scaled in amplitude for maximum base acceleration as determined by the earthquake history of the area and by the principles of engineering seismology.

14-3. Earthquake considerations for utility systems.

a. Earthquake resistant facilities. A fundamental precept of seismic design is that it is virtually impossible to design facilities to resist every earthquake without damage. Some damage must always be expected. The proper emphasis for good seismic design of exterior utility systems should then be on the development of earthquake resistant facilities for which measures have been taken to limit damage and to provide for expedient restoration of service. The two most important parameters in evaluating the seismic resistance of utility systems are site geology and structural configuration.

b. Site geology. The geology beneath a facility exerts considerable influence on the magnitude of the surface accelerations and deformations experienced during an earthquake. Current seismic building codes generally recognize this by taking soil type into account in seismic design (e.g., S-factor in chap 3). The best material on which to construct a utility system, from a strictly seismic standpoint, is sound rock. Unconsolidated sand and soft clay present the greatest hazards. Unconsolidated materials, either native soil or fill, present hazards of uncontrolled or differential settlements and/or lateral spreading. Even when utilities are built on good soils, considerable structural difficulties can develop. Large strain gradients can be induced at the interface between native soil and engineered fill and damage buried utilities if the fill is improperly compacted or is improperly benched or terraced. Seismically induced relative movement of the fill with respect to the native material can, through settlement or through slippage at the fill-native material interface, shear off an underground utility pipe.

c. Structural configuration. Structurally flexible underground systems have better earthquake resistance than rigid systems. Underground utilities can often be displaced during an earthquake, despite the relatively large-magnitude forces that may be required to initiate movement. A flexible system designed to accommodate the anticipated ground deformation will be less apt to fail during a major earthquake. Utility pipes rigidly attached to appurtenances can be sheared off by seismically induced differential settlements between the appurtenance structure and the adjoining pipes. Flexibility should be provided in utility pipes at entrances to and exits from heavy, rigid appurtenances, especially in systems dependent upon sound, uncracked pipe and connections for satisfactory performance. The same is true for pipes passing from native material into engineered fill. While it is not feasible to design the utility pipe to support some portion of the fill, the pipe can be made flexible at the interface to accommodate the anticipated relative movement.

14-4. General planning considerations. The considerations presented herein are guidelines for the planning of earthquake-resistant facilities. Since some damage should always be expected with major seismic activity, the considerations given here stress procedures to be followed to lessen the effects of seismic activity on utility systems and service.

a. Municipal-sized facilities. Such facilities should be planned and designed with due regard for possible seismic emergencies; disaster plans and equipment that may be required should be anticipated. Examples of emergency provisions and policies that may be anticipated in the planning stage are as follows:

(1) Specialized emergency equipment, such as mobile flame ionization detectors necessary for the detection of gas leaks, should be available.

(2) Structures that may be used as emergency operation centers should be equipped with battery or other standby power supply systems for communication with emergency vehicles by two-way radio.

(3) Provision should be made for the procurement of gasoline for emergency vehicles. Manually operated fuel pumps should be provided for use in pumping gasoline in the event of power failure.

(4) Emergency lights powered by a battery-driven or gasoline-driven generator should be provided for use in restoring utility service in the event of a power failure.

(5) The engineering staff responsible for the utility system should, from time to time, bring the emergency seismic disaster plans up to date.

(6) Seismic disaster plans should include contingency plans defining procedures for dealing with fires, landslides, and possible health hazards resulting from disrupted sanitary facilities.

b. Individual facilities. Examples of earthquake disaster procedures that may be implemented into the design in the planning stage are as follows—

(1) Persons having responsibility for the supervision and maintenance of critical facilities should establish earthquake disaster plans. Such plans will be subject to the approval of the utility authority.

(2) The utility authority should emphasize the importance of seismic disaster plans to the supervisory personnel of essential facilities. Seismic disaster plans should be emphasized to the same extent as fire protection plans.

(3) Capability should be established in critical facilities for water to be supplied from emergency reservoirs or wells.

(4) Personnel should be organized to shut off gas service, but only when they smell gas, and they should be instructed not to restore service until advised to do so by the utility authority. For essential facilities in Seismic Zones 3 and 4, an approved earthquake-actuated gas shut-off valve should be provided.

(5) Plans showing the locations of utility service lines in buildings should be kept in a safe and accessible location so as to be available for emergencies.

14-5. Specific planning considerations. The requirements given here are intended to be used in the planning of a utility system of either a major facility of municipal size or an individual facility of high priority in seismic areas. These requirements supplement applicable agency manuals.

a. General. Whenever practical, utility piping should avoid unstable ground or known earthquake faults, should not traverse native soil structures having widely varying degrees of consolidation, and should not pass from natural ground to unstable fill.

b. Water. Where possible, it is preferable to have at least two independent sources of water supply for municipal-sized facilities in Zones 2, 3, and 4 (refer to chap 3, para 3-4 for seismic zone maps). When water is furnished by a public utility company, a secondary supply may be provided from on-site wells or from an on-site reservoir. When the water source consists of an on-site well, an additional well should be drilled at a point as widely separated as is practical from the first well. Decentralization of municipal-sized waterworks will provide a more flexible water supply network and thus promote a more dependable water supply during a disruptive earthquake. Where practicable, on-site water distribution systems in Zones 2, 3, and 4 should be laid out in a grid pattern. In the event service is disrupted in one section of the grid, water may be drawn from any of several adjacent sections. The grid will be valved to prevent loss of stored emergency supply, to permit the isolation of breaks, and to facilitate the emergency distribution of water (e.g., fig 14-7).

c. Gas. Provisions will be made such that installations normally supplied by public utility systems in Zones 2, 3, and 4 for which a gas outage would be critical can be supplied by a liquid petroleum gas (LPG) standby system. Gas distribution networks in Zones 1, 2, 3, and 4 will be valved so that breaks in gas lines may be isolated.

d. Power. Two independent sources of support are less likely to be available for electrical distribution systems than for water and gas supply systems. For Zones 2, 3, and 4, standby power generating facilities should be maintained for use in critical areas such as essential systems for hospitals, computer centers, communication systems, etc. in the event of normal power supply disruption. Such standby systems may consist of diesel- or gasoline-engine-driven electric generators located within the building.

e. Sanitary sewers. The design of sewer systems for municipal-sized facilities located in Zones 2, 3, and 4 will incorporate provisions to eliminate as much as practicable the possibilities of wastewater flooding, contamination of groundwater, and contamination of open water storage reservoirs, should rupture occur to sewers and sewage disposal structures. The design of sewage treatment facilities in Zones 2, 3, and 4 will consider the possibility of decentralizing treatment facilities to minimize possible damage. The practicability of decentralization will be weighed against increased operating, maintenance, and initial costs. In Zones 2, 3, and 4 a means will be provided to rapidly empty and bypass sewage treatment and sewage pumping plant facilities. Should it be impossible to dump raw sewage into emergency outfalls, some simple method of treating the raw sewage should be provided to safeguard health and prevent a nuisance. Mobile pumping equipment should be available for pumping raw sewage into the nearest sewer collector in the event of a pumping plant breakdown.

f. Storm sewers. More damage to storm sewers and storm sewer facilities can be tolerated than to sanitary sewers and sewage disposal facilities. Cracked or damaged storm sewers in most instances present little danger to health or property. In certain areas where damage to equipment can result from flooding or from infiltration and settlement of fill, care in the design of the storm sewer system must be taken in order to minimize the effects of cracked or broken pipes.

g. Miscellaneous systems. It is not feasible to provide secondary distribution systems for central steam, motor vehicle fuel, air, and similar utility systems, but all planning considerations given above, where applicable, will apply to these systems.

14-6. Design considerations. The provisions of this paragraph are intended to supplement rather than supersede the provisions of the various military design manuals and other applicable government criteria.

a. Materials and construction. Specifications for materials and construction will be governed by the applicable government criteria.

b. Pipe flexibility. No section of pipe in Zone 2, 3, or 4 will be held fixed while an adjoining section is free to move, without provisions being made to relieve strains resulting from differential movement, unless approved calculations show that the pipeline can resist the stresses caused by the predicted or estimated pipe movements. Flexibility will be provided by the use of flexible joints or couplings (e.g., figs 14-1 through 14-6) at the following points:

(1) Immediately adjacent to both sides of the surface separating different types of soil having widely differing degrees of consolidation.

(2) At all points that can be considered to act as anchors.

(3) At all points of abrupt change in direction, and at all tees.

c. Water. Buildings housing essential functions, such as hospitals, will be provided with two or more service lines. The service lines will be connected to separate sections of the grid so as to provide continued service in the event one section of the grid is isolated. Services will be interconnected in the building with check valves to prevent backflow. Flexible couplings or flexible connections will be used between valves and lines for valve installations on pipes 3 inches or larger in diameter. In remote areas or at a site with a single water source, auxiliary storage would be an acceptable alternative.

d. Gas. When secondary or standby gas supply systems cannot be justified for a site, gas distribution networks for buildings in Zones 2, 3, and 4 housing essential functions dependent upon gas will include an aboveground valved and capped stub. Provision will be made for attachment of a portable, commercial-sized gas cylinder system to this stub. For essential facilities in Seismic Zones 3 and 4, an earthquake-actuated shut-off valve will be provided. Provisions will be made for the expedient restoration of service and for the prevention of pilot light leaks when service is restored. If an earthquake-actuated shut-off valve presents the possibility of disrupted service in buildings where the fire hazard is small, a manually operated shut-off valve will be installed. The location and operation of such a valve will be made known to the supervisory personnel of the building.

e. Power. Individual aboveground components of electrical utility systems will be designed for seismic forces under the provisions of chapter 12. Slack will be provided in underground cables whenver such cables enter or exit rigid appurtenances. The provisions of paragraph 14-6*b* will not be held applicable to underground electrical utility conduits.

f. Storm sewer facilities. While it is desirable to have flexibility in storm sewer pipe, such flexibility cannot, in most instances, be provided without inordinate cost. The provisions of paragraph 14-6*b* will not be held applicable to storm sewer pipes. Every attempt should be made, however, to provide flexibility in the connection of storm sewer pipes to rigid appurtenances in Zones 2, 3, and 4.

14-7. Seismic details. Figures 14-1 through 14-7 are provided to show acceptable seismic details. Some of the plates show examples of good and poor seismic details. Other plates merely illustrate details that have exhibited good seismic details and resistance. Where required by the provisions of this chapter, these recommended seismic details or similar equivalent details will be incorporated in the utility design.

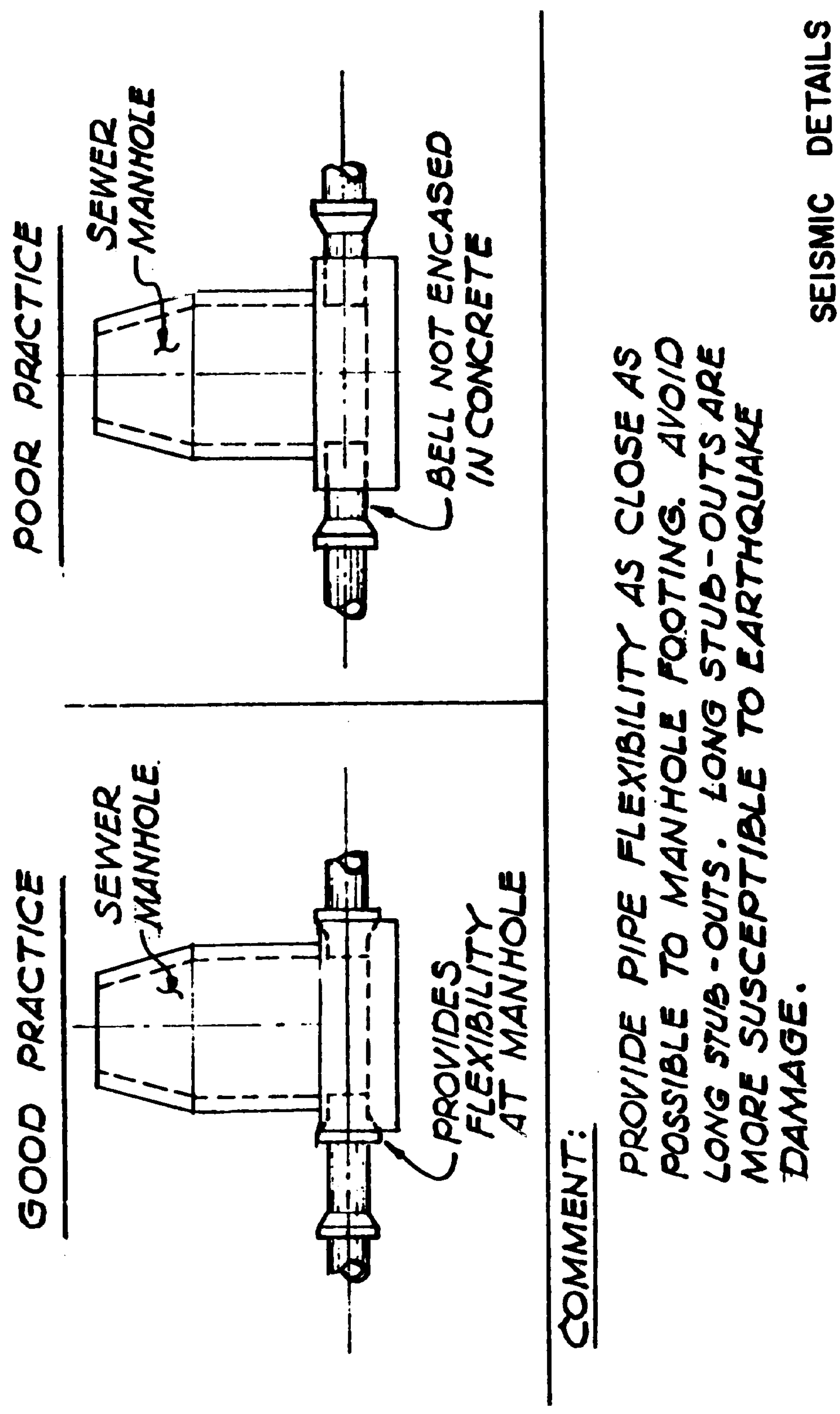


Figure 14–1. Manhole footing.

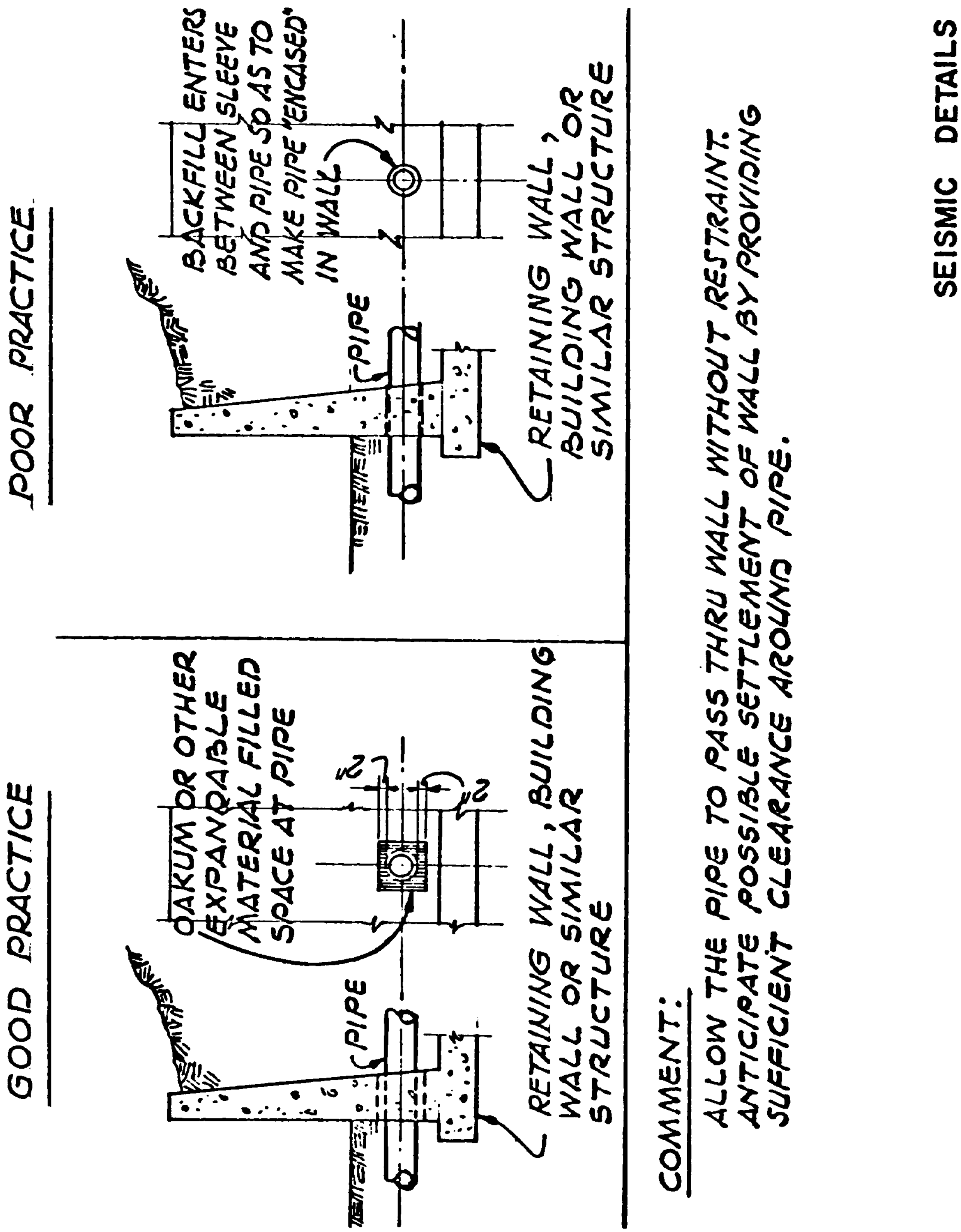


Figure 14–2. Pipe through wall.

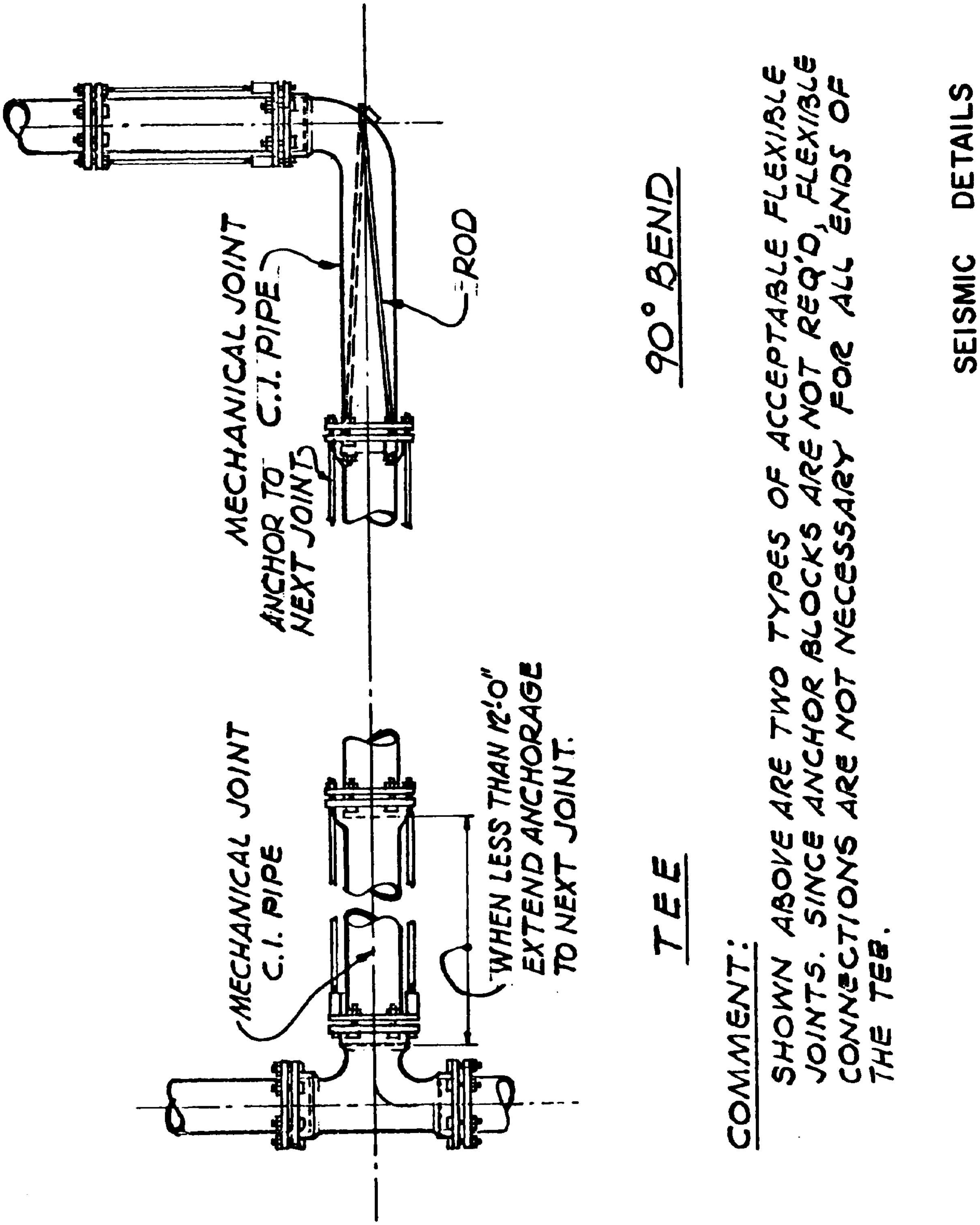
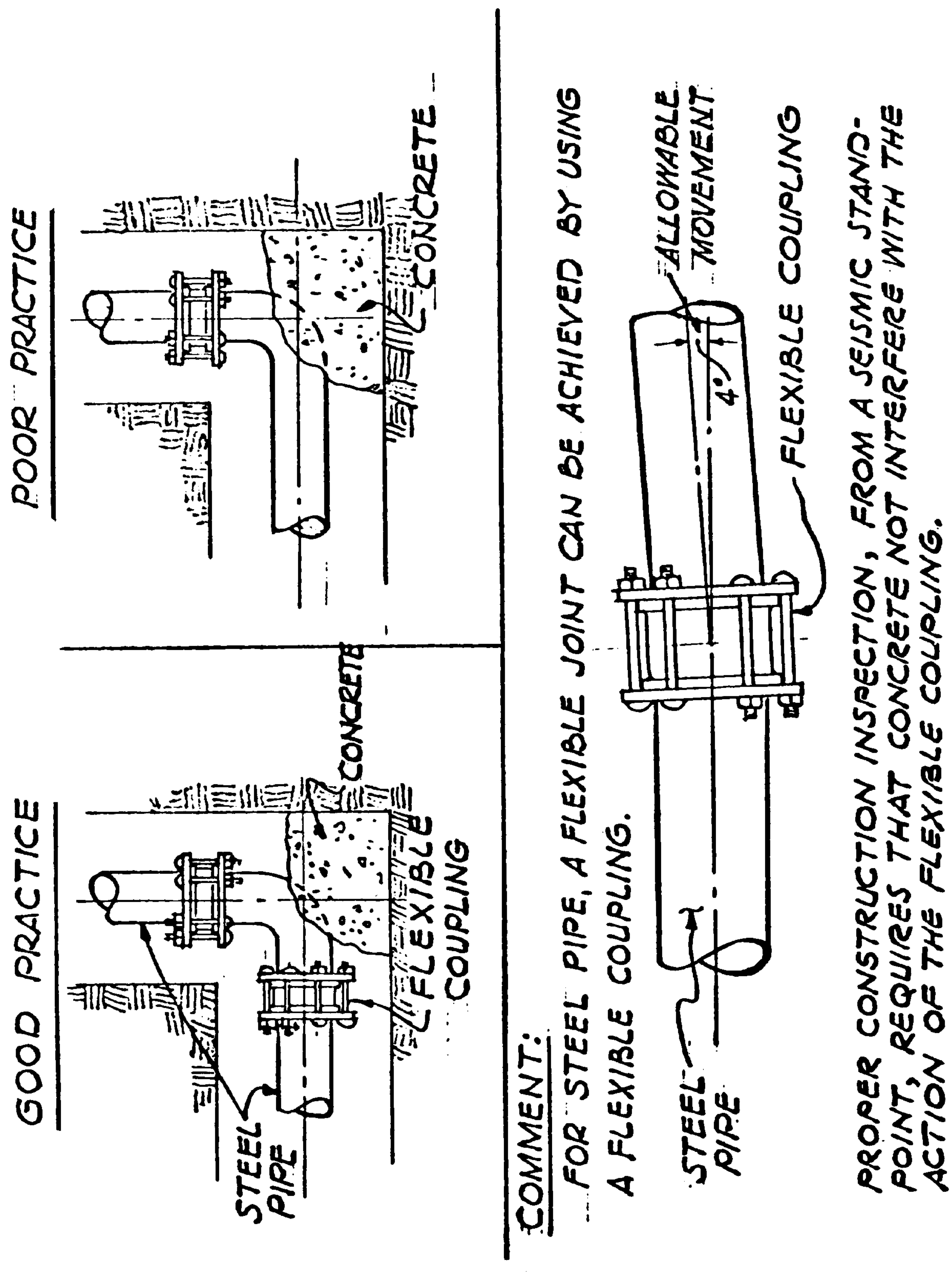
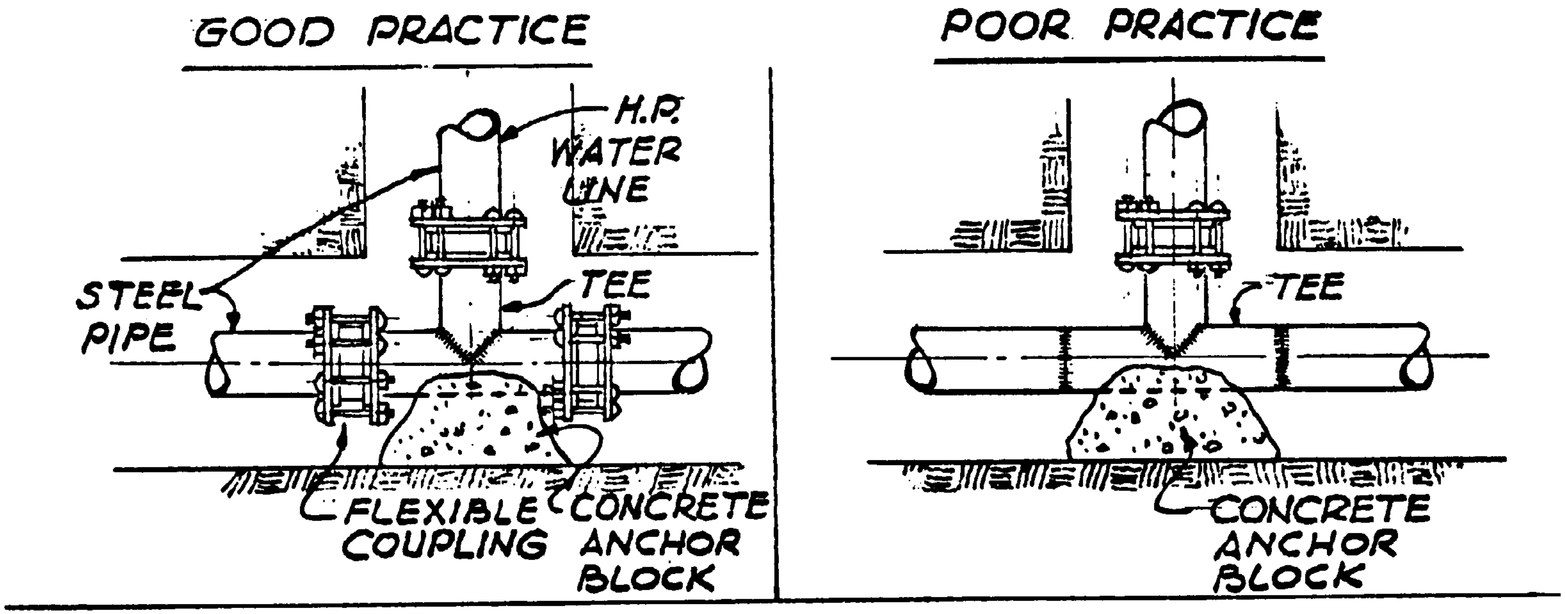


Figure 14–3. Flexible joints.



SEISMIC DETAILS

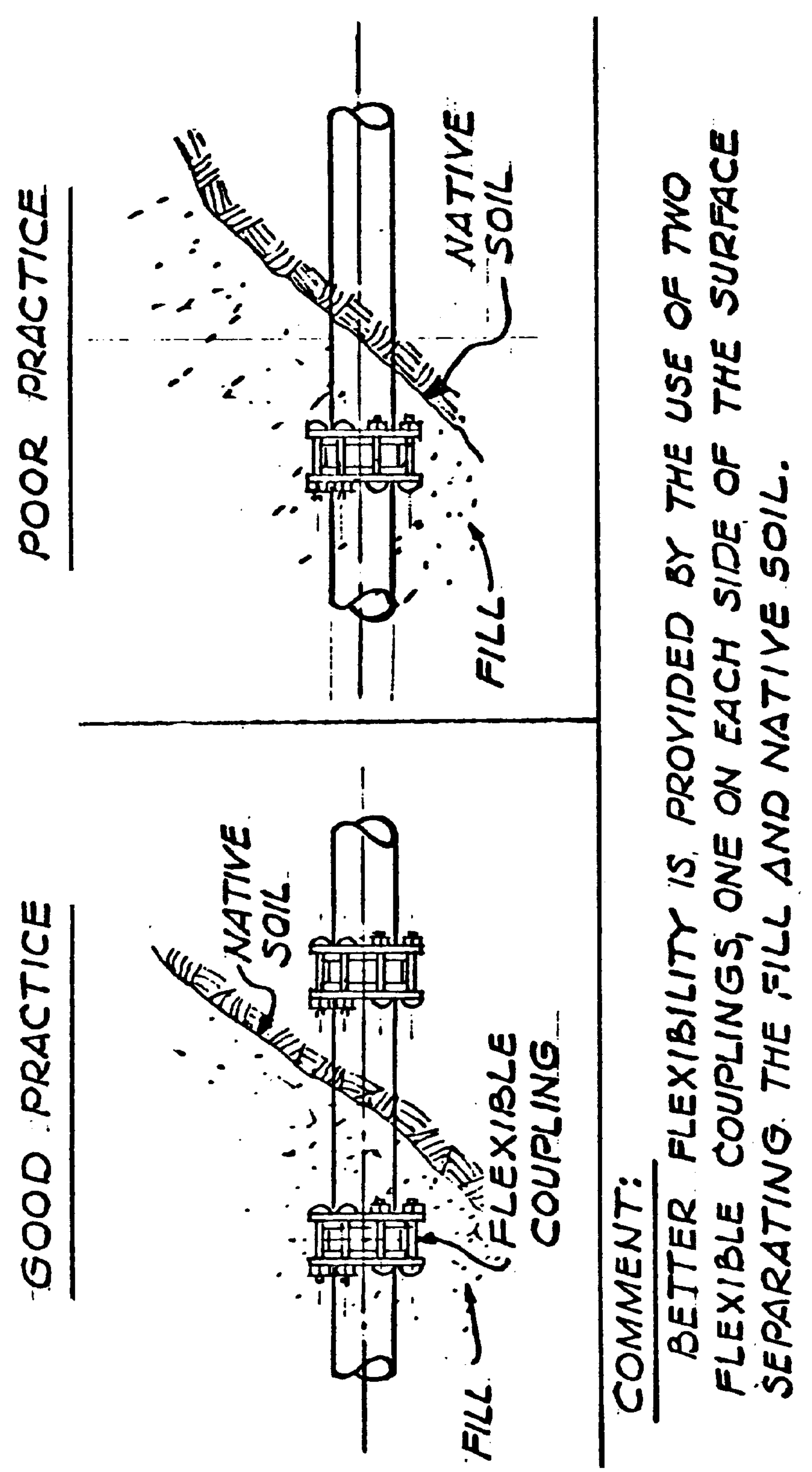


COMMENT :

GOOD SEISMIC DESIGN PRACTICE REQUIRES THE USE OF THREE FLEXIBLE COUPLINGS AT AN ANCHORED TEE. THE CONCRETE ANCHOR BLOCK USED TO PREVENT THE HIGH-PRESSURE WATER LINE FROM SEPARATING ALSO PREVENTS MOVEMENT UNLESS FLEXIBILITY IS PROVIDE BY FLEXIBILE COUPLINGS.

SEISMIC DETAILS

Figure 14-5. Coupling at tee.



SEISMIC DETAILS

Figure 14–6. Fill-native material interface.

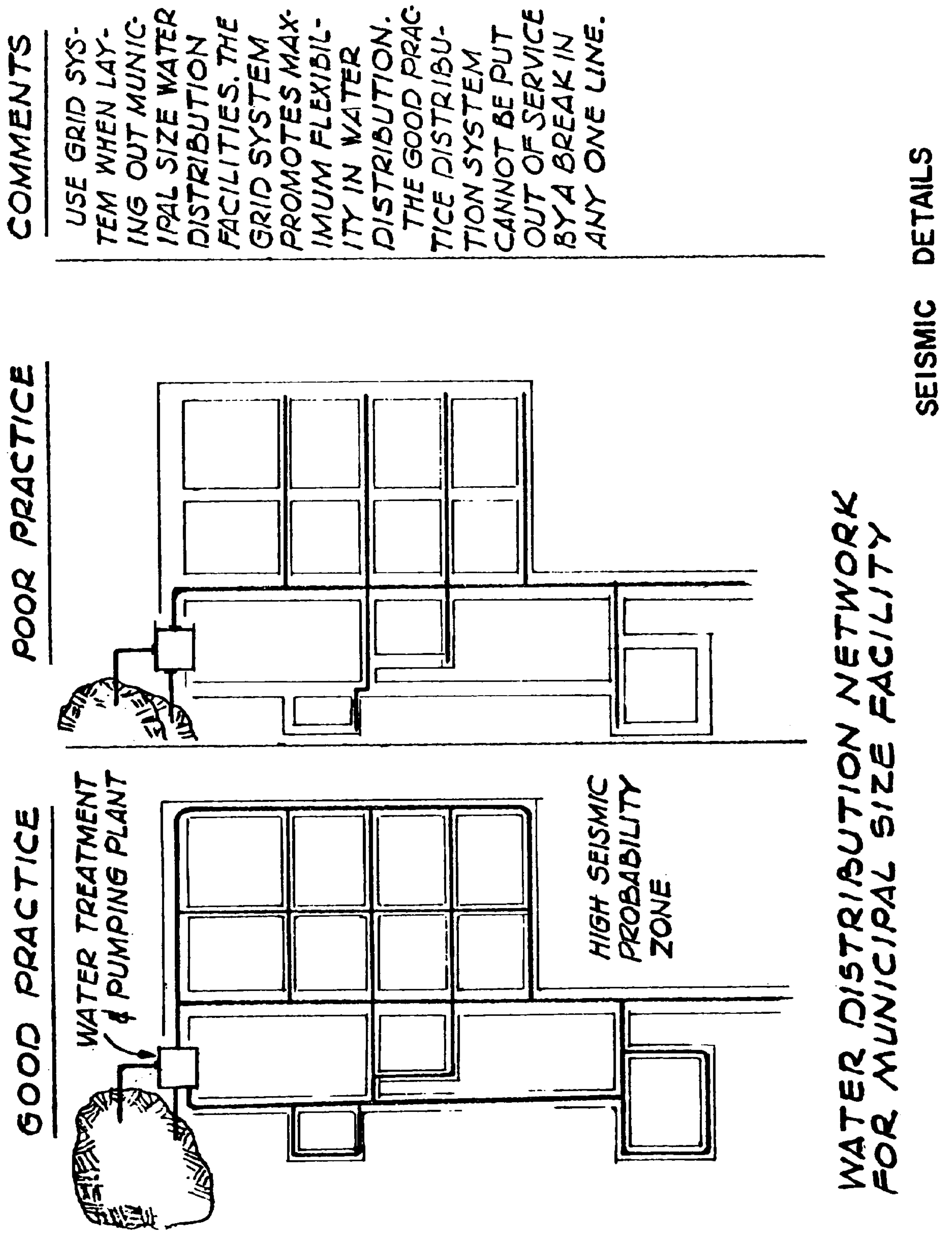


Figure 14–7. Water distribution network.